

UIC.02USU1 (CV107/NPU)

REMARKS

Claims 1-14 are currently pending in the above-identified patent application. Claim 1 has been amended. In the Examiner's Response to Arguments found on page 4 of the Office Action dated August 08, 2005, the Examiner stated that: "The claims do not recite that the emitted coherent radiation is in the x-ray band. It is stated in the claim preamble that the device may be used to emit radiation in the x-ray band, but this statement appears to be only an intended use for the device." Applicants have amended claim 1 in accordance with the Examiner's kind suggestion. No new matter has been added by this amendment, since support therefor may be found on page 6, lines 14-29, of the subject Specification, as originally filed.

In the subject Office Action, the Examiner rejected claims 1-6, and 8-13 under 35 U.S.C. 103(a) as being unpatentable over Silvast (U.S. Patent No. 4,592,064) in view of Lo (U.S. Patent No. 4,940,893), since the Examiner asserted that claims 1 and 8, and FIGURE 1 of Silvast discloses generating pulsed laser (30) radiation with a chosen power, pulse width and wavelength, generating atoms/ions and directing the laser radiation into the atoms/ions so that an atomic excitation is produced where selected inner-shell electron atomic electrons are removed from the atoms without the removal of all of the electrons in the next outermost shell, thereby generating a hollow atom array having a population inversion from which a chosen wavelength of radiation is emitted and amplified (Col. 2, lines 47-49), and wherein a self-trapped plasma channel region (28) having a nonlinear mode of confined propagation for the chosen wavelength of amplified radiation is formed.

The Examiner continued by stating that Silvast does not disclose controlling atomic clusters; however, that Lo discloses generating atomic clusters having a chosen size and density and controlling the density of the atomic clusters (Col. 3, lines 55-62). The Examiner also asserted that Lo discloses controlling the density of plasma electrons (Col. 4, lines 26-28) resulting in control of the pulse width, wavelength and power of the laser radiation such that the chosen wavelength of amplified radiation is tunable over the wavelengths for the hollow atom array.

UIC.02USU1 (CV107/NPU)

Claims 2 and 9, were rejected since the Examiner asserted that Silfvast discloses choosing the atomic collision cross section to minimize the laser intensity required to excite substantially all of the atoms in the cluster (Col. 8, lines 16-34).

Claims 3-4 and 10-11 were rejected since the Examiner stated that Silfvast discloses choosing the pulse width such that atomic excitation occurs on a timescale which is short compared with recombination processes in the plasma produced (Col. 4, lines 14-21).

Claims 5 and 12 were rejected since the Examiner asserted that Silfvast discloses selecting the atoms so a chosen wavelength is emitted and amplified (Col. 2).

Claims 6 and 13 were rejected since the Examiner stated that Silfvast discloses the use of heavy atoms (Col. 2, lines 26-39), the Examiner concluding that it would have been obvious to one of ordinary skill in the art at the time of the invention to use controlled atomic clusters as disclosed in Lo with the device disclosed in Silfvast to obtain a laser emitting light in the x-ray spectrum (Col. 3, lines 36-41).

Applicants respectfully disagree with the Examiner concerning these grounds of rejection for the reasons to be set forth hereinbelow.

Claims 7 and 14 were rejected under 35 U.S.C. as being unpatentable over Silfvast in view of Lo as applied to the claims above and further in view of Ota (U.S. Patent No. 6,594,334), since the Examiner stated that Silfvast and Lo do not disclose Xe atoms, while Ota discloses the use of Xe atoms for a laser (Abstract) in the 248 nm spectrum (Col. 5, lines 26-30) to suppress the deterioration of optical characteristics (Col. 2, line 54). The Examiner concluded that it would have been obvious to one of ordinary skill in the art at the time of the invention to use Xe atoms as disclosed in Ota for the atomic clusters disclosed in Lo for improved suppression of optical deterioration as disclosed in Ota.

Applicants respectfully disagree with the Examiner concerning this ground of rejection for the reasons to be set forth hereinbelow.

Reexamination and reconsideration are respectfully requested.

UIC.02USU1 (CV107/NPU)

Subject claim 8, as originally filed, recites in part: "means for directing the laser radiation into the atomic clusters wherein rapid atomic excitation is generated having selected inner-shell electron atomic electrons being removed from the atoms without the removal of all of the electrons in the next outermost shell, thereby generating a population inversion from which a chosen wavelength of x-radiation is amplified or spontaneously generated, and wherein the laser generated or amplified radiation is propagated in a self-trapped plasma channel region additionally having a nonlinear mode of confined propagation for the chosen wavelength of x-radiation; whereby if the density of said atomic clusters, the density of plasma electrons, and the laser radiation are simultaneously controlled, the spectrum of x-ray amplification is defined." (emphasis added by applicants).

Turning now to the rejection of claims 1-6, and 8-13 under 35 U.S.C. 103(a) as being unpatentable over Silfvast (U.S. Patent No. 4,592,064) in view of Lo (U.S. Patent No. 4,940,893), applicants wish to direct the Examiner's attention to Fig. 3 and Col. 3, lines 48-60, of Silfvast, where it is stated: "The target 36 is mounted on a rod 38 which extends through the other end of transverse segment 12 for manipulation purposes. The focused output of laser 30 impinges upon the target 36 and generates soft X-rays 40 which are absorbed by the active medium 28 in a fashion described later. Optionally, a laser 42 may be coupled into the resonator, and hence into the active medium, via a beam splitter 44. The laser 42 may be serve as a probe laser for measuring the optical gain of the laser of amplifier, or it may serve as a transfer laser for pumping the photoionized species to a higher energy level (also described in detail later)." Further, in Col. 4, lines 7-36, it is stated: "In this case, the intensity of the X-rays should also be sufficient to create a population inversion (optical gain) between the upper laser level and the lower laser level, the energy separation of which corresponds to the wavelength of the optical output 24." To this end the X-rays 40 are supplied as pulses, the duration of which should be less than the lifetime for the upper laser level. Pulse durations ranging from about 10 nsec to 70 psec have been found useful, but even shorter or perhaps longer pulse duration may be suitable depending upon the particular active medium and the density of electrons generated by the X-rays (i.e., electron collisions with

UIC.02USU1 (CV107/NPU)

ions in the upper laser levels tend to shorten the lifetime of that state.). As an illustration, consider the energy level scheme for Cd shown in FIG. 3. Illustratively, the neutral Cd ground state $4d^{10}5s^2\ ^1S_0$ is the target state, the singly ionized Cd⁺ doublet states $4d^95s^2\ ^2D_{3/2}$ and $^2D_{5/2}$ are the upper state levels, and the singly ionized Cd⁺ doublet states $4d^{10}5p\ ^2P_{1/2}^0$ and $^2P_{3/2}^0$ are the respective lower laser levels which are optically coupled by allowed transitions at 3250 Å and 4416 Å, respectively. Prior to excitation, the active medium 28 consists primarily of neutral Cd atoms Cd⁰ in the ground state. The X-rays 40 are absorbed by the neutral Cd atoms in the ground state (in this case, the target state) causing d-electrons in the fourth shell to be preferentially removed from the atoms leaving them as a singly ionized species Cd⁺ in the upper laser levels. (emphasis added by applicants).

In Col 4, lines 48-55 of Silfvast it is stated that: "Note that the energy of the X-rays need not equal the energy difference between the target state and the upper laser levels. In general, it is considerably greater. The excess energy, corresponding to the difference between the actual X-ray energy and the energy separation for the target state and the upper laser levels, is taken up by the removed 4d electrons. Consequently, a broadband source of X-rays is suitable.", and in Col. 4, line 65 to Col. 5, line 13, it is stated: "In an alternative embodiment, the laser 42 may be employed as a transfer laser to increase the energy of the Cd⁺ ions from the $^2D_{3/2}$ and $^2D_{5/2}$ levels to higher energy states, the $4d^95s5p\ ^2P_{1/2}^0$ and $^2P_{3/2}^0$ states, which are the upper laser levels. These states typically have lifetimes of a few nanoseconds or less and, as noted above are not metastable. In this configuration the 2D states are an intermediate level rather than the upper laser level, and the $4d^{10}5s\ ^2S_{1/2}$ Cd⁺ ground state is the lower laser level. The upper laser levels are reached by pumping the 2D intermediate states with a transfer laser at 2008 Å, 2205 Å or 2284 Å. The transfer laser should apply to the active medium optical pulses of duration shorter than the lifetime of the upper laser level. Well-known dye lasers and Raman shifted excimer lasers are suitable transfer lasers. Lasing is expected to occur at 838 Å and 840 Å." (emphasis added by applicants).

In EXAMPLE 1 of Silfvast, Col. 7, lines 3-8, it is stated that: "A 300 mJ pulse at 1.06 μm from a Q-switched Nd:YAG laser 30 was directed down the axis of

UIC.02USU1 (CV107/NPU)

transverse segment 12 and was focused with a 25 cm focal length lens 32 to a 200 μm diameter spot onto a tungsten target 36 located near the intersection between transverse segment 12 and longitudinal segment 10." (emphasis added by applicants).

Although the Examiner used claims 1 and 8 and FIGURE 1 of Silfvast in the rejection of claims 1-6, and 8-13 under 35 U.S.C. 103(a), paragraph 6 of 35 U.S.C. 112 states: "An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material or acts in support thereof, and such a claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof." Thus, applicants have identified the corresponding structure and material in the Specification of Silfvast.

Clearly, Silfvast teaches: (1) incoherent, soft X-ray photoionization, generated by high-power, pulsed laser-produced plasma, for preferentially removing inner-shell d-electrons from neutral atoms leaving them singly ionized in a 2D state, and producing a population inversion with respect to lower lying 2p state irradiation, and giving rise to visible and ultraviolet laser radiation in species such as Cd and Zn; (2) the laser responsible for producing soft X-ray photoionization is focused onto a metal target, such as a tungsten target; and (3) the use of an optional transfer laser to pump the excited D-state to a still higher P-state from which transitions to an S-ground state permit lasing at VUV wavelengths of less than 1000 Å, in species such as Cd, Zn and Hg. Thus, the pump laser does not directly excite the lasing medium in Silfvast. Rather, incoherent X-rays emitted in virtually all directions from a target upon which the pump laser radiation impinges are absorbed by the lasing medium. An optional second laser may be used to obtain shorter wavelength laser radiation; however, this laser does not provide the photoionization. Thus, Silfvast teaches away from the present claimed invention. Present independent claims 1 and 8 recite directing the laser radiation into the atomic clusters (lasing medium) wherein rapid atomic excitation is generated having selected inner-shell electron atomic electrons being removed from the atoms without the removal of all of the electrons in the next outermost shell, thereby generating a population inversion from

UIC.02USU1 (CV107/NPU)

which a chosen wavelength of x-radiation is amplified or spontaneously generated. Moreover, the laser generated or amplified radiation is propagated in a self-trapped plasma channel region additionally having a nonlinear mode of confined propagation for the chosen wavelength of x-radiation. Nowhere in Silfvast is such a plasma channel identified or rendered obvious. Rather, the action of the pump laser radiation on the metal target generates an amorphous plasma near the surface of the target.

Lo teaches a method and apparatus for forming coherent clusters of atoms or molecules. In Col. 1, beginning at line 63 to Col. 2, line 5 of Lo, it is stated that: "The Coherent clusters may be formed by passage through a nozzle of a higher pressure gas whereby to form the clusters in a lower pressure region at exit from the nozzle. The coherent clusters may be neutral, positive or negatively charged. Positively charged clusters may be formed by the impact of an electron beam or other charged particles in beam form thereon. Negatively charged clusters may be formed by nucleation processes during the free expansion phase around electrons. These electrons may be generated by photoelectric effects initiated by light from a laser." In Col. 3, lines 23-44 of Lo it is stated that: "Providing seed ions will assist the nucleation process and a larger cluster size may result in that case. To generate ions, microwave radiation may be used to generate ions. It is also possible to use an arc. Both of these methods will result in appearance of an unacceptable heat source for a liquid helium temperature environment. Ions may, however, be created immediately outside a nozzle by the impact of an electron beam. Ions created just outside the nozzle will be cooled together with the neutral molecules during free jet expansion. A coherent ion-cluster beam is preferable to coherent neutral cluster beam because one can accelerate it to higher energies. Hence, a coherent ion-cluster beam has great advantage over other coherent neutral beams. It is well known that it is extremely difficult to construct a laser emitting in x-ray region although a laser emitting invisible light has been achieved for more than a quarter century. For the coherent ion-cluster beam, there is no difficulty in increasing its energy per particle, because it can be accelerated like any other charged beam in a linear accelerator." (emphasis added by applicants).

UIC.02USU1 (CV107/NPU)

Lo clearly teaches away from generating x-radiation using neutral clusters of atoms or molecules as is recited in the present claims, since Lo states that it is extremely difficult to generate such radiation using uncharged clusters.

The Examiner combined Silfvast and Lo to reject claims 1-6 and 8-13, 2 and 9, 5 and 12, and 6 and 13 under 35 U.S.C. 103(a). Since applicants believe that both Silfvast and Lo teach away from the present invention, applicants respectfully believe that the Examiner has improperly combined the Silfvast and Lo references.

Claims 7 and 14 were rejected under 35 U.S.C. 103(a) as being unpatentable over Silfvast in view of Lo as applied to the claims above, and further in view of Ota (U.S. Patent No. 6,594,334), since the Examiner stated that Ota discloses the use of Xe atoms for a laser in the 248 nm spectrum (Col. 5, lines 26-30) to suppress the deterioration of optical characteristics (Col. 2, line 54).

Ota describes the generation of 100 nm incoherent light from Xe gas using focused laser radiation as an excitation source for purposes of lithography. The present invention generates coherent x-radiation using neutral Xe clusters.

Since Silfvast and Lo teach away from the present claimed invention, applicants respectfully believe that the Examiner has improperly combined these references in the rejection of claims 7 and 14 under 35 U.S.C. 103(a) as being unpatentable over Silfvast and Lo in view of Ota. Moreover, the combination of Ota with Lo and Silfvast does not render obvious the present claimed invention.

Therefore, applicants respectfully believe that the Examiner has failed to make a proper *prima facie* case for an obviousness-type rejection under 35 U.S.C. 103(a), since the Examiner has combined two references each of which clearly teaches away from the present claimed invention.

UIC.02USU1 (CV107/NPU)

For these reasons, applicants believe that claims 1-14, as amended, are in condition for allowance or appeal, the former action by the Examiner at an early date being earnestly solicited. Reexamination and reconsideration are respectfully requested.

Respectfully submitted,

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